

Thermopile Area Array Readout, Phase II

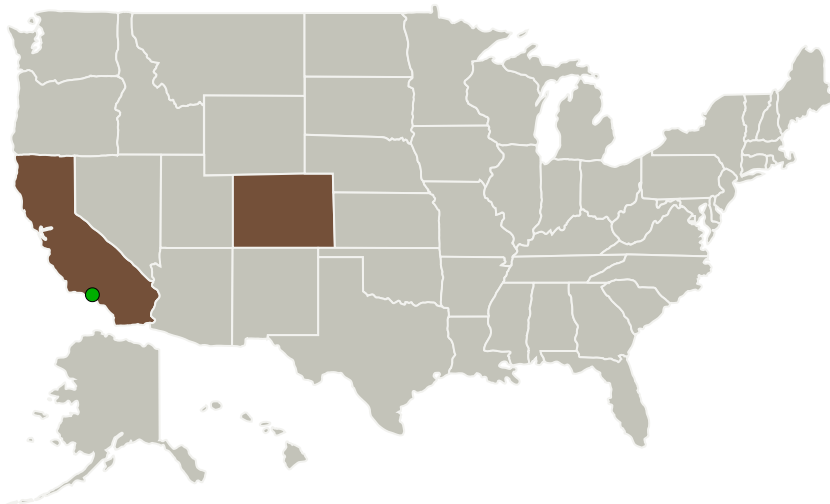
Completed Technology Project (2014 - 2016)



Project Introduction

NASA/JPL thermopile detector linear arrays, wire bonded to Black Forest Engineering (BFE) CMOS readout integrated circuits (ROICs), have been utilized in NASA missions such as the Mars Climate Sounder (MCS) and the Diviner Lunar Radiometer Experiment (DLRE). JPL linear array thermopile detectors are fabricated by bulk micro-machining. Micro-machined thermopiles bump bonded to a ROIC are desirable for area (2-D) focal plane arrays (FPAs) because the architecture provides both high detector fill factor and circuit fill factor in the pixel. The proposed innovation is to develop an area array ROIC compatible with bump bondable micro-machined thermopile detectors. The ROIC will be compatible with JPL Bi-Te/Bi-Sb-Te micro-machined thermopile detector arrays to meet requirements of future NASA thermal instruments requiring D-Star > 4 x 10⁹ Jones. Radiation hard-by-design (RHBD) will be utilized with 180 nm CMOS for low 1/f noise readout, operating temp 77-300 K, radiation hardness and noise immunity with on-ROIC ADC. A small pixel pitch and binning is utilized to cover a desired wavelength detection range of 20 μm – 100 μm. The Phase I ROIC array design will be fabricated on Phase II.

Primary U.S. Work Locations and Key Partners



NASA SBIR/STTR Technologies

Thermopile Area Array Readout
Black Forest Engineering, Colorado Springs, CO
PI: Dr. Steve Gaudin
Proposal No. N14J000284

Identification and Significance of Innovation

Develop an area array ROIC compatible with JPL Bi-Te/Bi-Sb-Te thermopile detectors to meet requirements of future NASA thermal instruments requiring D-Star > 4 x 10⁹ Jones and detection wavelength from 20-100 μm. Radiation hard-by-design (RHBD) will be utilized with 180 nm CMOS for low 1/f noise readout, operating temp 77-300 K, radiation hardness and noise immunity with on-ROIC ADC. The 2-D thermopile area ROIC will be fabricated on Phase II.

Estimated TRL at beginning and end of contract (Range 1 End 4)

Technical Objectives and Work Plan

- Telecon with NASA/JPL to finalize DSTAR sensor requirements
- Test Phase I ROIC-level experiments for low noise
- ROIC design/verify and performance prediction
- ROIC Process (180 nm CMOS) including silicon bumps
- Design and build PC controlled ROIC test system
- ROIC characterization (ROIC performance and 2-Mrad TID tolerance capability when operating at cryo temperature)
- Deliver ROIC to NASA/JPL for detector integration
- Document performance and prepare Phase II final report

NASA Applications

Thermopile area array LWIR/VLWIR sensors are required in future thermal instruments supporting earth and planetary observing missions.

Small Business Applications

Thermopile making focal plane arrays will have low 1/f noise and accurate radiometry for thermal image diagnostic equipment.

Final Contact:

Steve Gaudin 719-593-8551 ext. 100

NON-PROPRIETARY DATA

Broadband IR absorber

Indium Bump Interconnect

BFE ROIC Pixel for Thermopiles

ROIC for JPL Bi-Te/Bi-Sb-Te area array thermopiles

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Organizations Performing Work	Role	Type	Location
Black Forest Engineering, LLC	Lead Organization	Industry	Colorado Springs, Colorado
● Jet Propulsion Laboratory(JPL)	Supporting Organization	NASA Center	Pasadena, California

Primary U.S. Work Locations	
California	Colorado

Project Transitions

▶ **April 2014:** Project Start

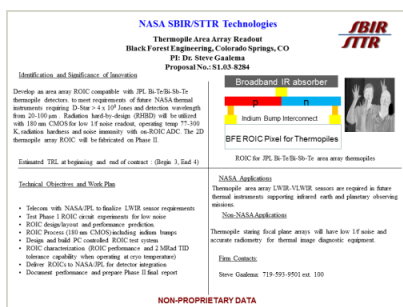
✓ **April 2016:** Closed out

Closeout Summary: Thermopile Area Array Readout, Phase II Project Image

Closeout Documentation:

- Final Summary Chart Image(<https://techport.nasa.gov/file/140713>)

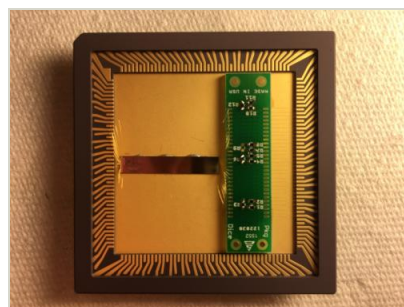
Images



Briefing Chart Image

Thermopile Area Array Readout, Phase II

(<https://techport.nasa.gov/image/134406>)



Final Summary Chart Image

Thermopile Area Array Readout, Phase II Project Image

(<https://techport.nasa.gov/image/134769>)

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Black Forest Engineering, LLC

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

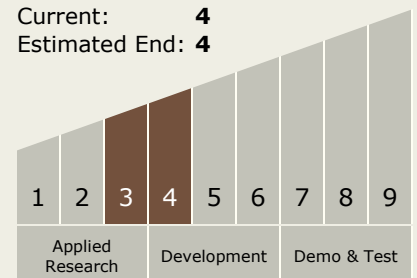
Carlos Torrez

Principal Investigator:

Stephen Gaalema

Technology Maturity (TRL)

Start: **3**
Current: **4**
Estimated End: **4**



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Technology Areas

Primary:

- TX08 Sensors and Instruments
 - └ TX08.1 Remote Sensing Instruments/Sensors
 - └ TX08.1.1 Detectors and Focal Planes

Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System